



Posterior corneal aberrations and their compensation effects on anterior corneal aberrations in keratoconic eyes

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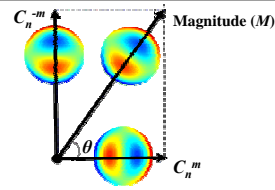
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Introduction

In normal eyes, the posterior corneal aberration has a relatively small impact on optical quality of the eye due to the smaller refractive index difference between cornea and aqueous. However, in keratoconic eyes, contribution of the posterior corneal aberration to the total ocular aberration becomes more significant with an increase in corneal irregularities. Some of the anterior corneal aberration can also be compensated by the posterior corneal aberration. **The goal of this study is to characterize posterior corneal aberrations in keratoconic (KC) eyes and to investigate the compensatory effects between anterior and posterior corneal surfaces.**

Vector analysis of aberration

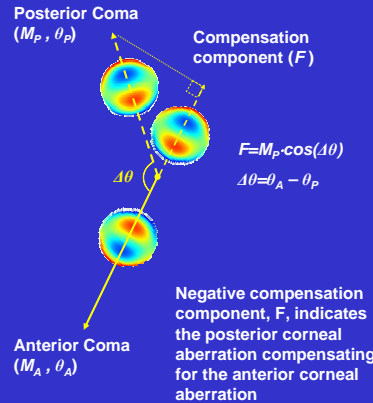


$$M = \begin{cases} \sqrt{(C_n^{-m})^2 + (C_n^m)^2} & (m \neq 0) \\ |C_n^0| & (m = 0) \end{cases}$$

$$\theta = \begin{cases} \frac{1}{m} \tan^{-1} \left(\frac{C_n^{-m}}{C_n^m} \right) & (C_n^m > 0) \\ \frac{1}{m} \left(\tan^{-1} \left(\frac{C_n^{-m}}{C_n^m} \right) + 180^\circ \right) & (C_n^m < 0) \\ \frac{1}{m} 90^\circ & (C_n^m = 0, C_n^{-m} > 0) \\ \frac{1}{m} 270^\circ & (C_n^m = 0, C_n^{-m} < 0) \end{cases}$$

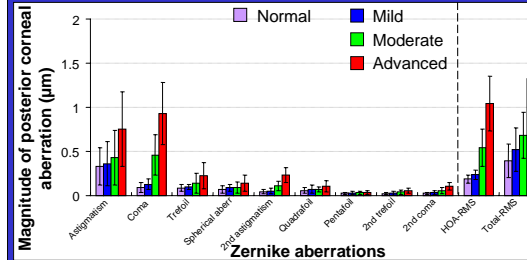
Campbell CE. *Optom Vis Sci.* 2003;80:79-83

Quantifying compensation effect between anterior and posterior cornea

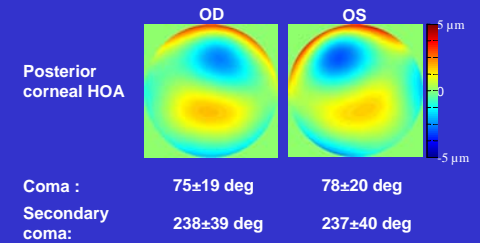


Characterization of posterior corneal aberration

Posterior aberration in KC eyes is significantly larger than in normal eyes.



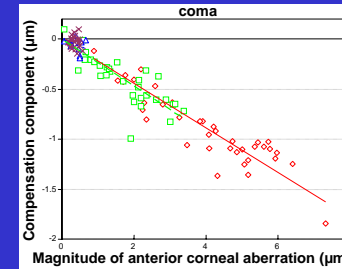
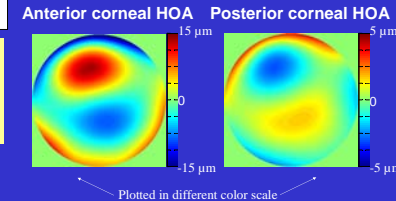
Mirror symmetry between OD and OS was observed in advanced KC eyes.



Posterior corneal compensation effects

Angle difference ($\Delta\theta$) between anterior and posterior aberration was close to 180 deg (168 deg for coma) indicating the compensation effect between the cornea surfaces.

Strong linear correlation between the anterior corneal HOA and the compensation component was observed especially in moderate and advanced KC eyes.



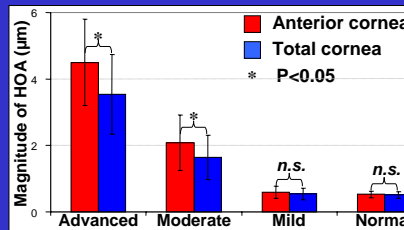
aberration	coma	trefoil	spherical aberr	2 nd astigmatism	2 nd coma
advanced	k: -0.22 (R ² : 0.82)	-0.17 (0.40)	-0.20 (0.74)	-0.21 (0.33)	-0.16 (0.25)
moderate	k: -0.24 (R ² : 0.64)	-0.19 (0.49)	-0.19 (0.20)	-0.24 (0.17)	-0.15 (0.44)
mild	k: -0.14 (R ² : 0.20)	-0.11 (0.13)	-0.33 (2e-3)	-0.11 (2e-3)	-0.08 (0.04)
normal	k: -0.06 (R ² : 0.07)	-0.12 (0.06)	-0.18 (0.02)	0.01 (1e-3)	-0.01 (0.01)

k: Ratio of compensation component to the anterior corneal aberration
R²: Determination factor

Subjects and Methods

- Subjects
 - 31 normal eyes
 - 82 KC eyes: 37 advanced, 31 moderate, 14 mild
- Corneal aberration was computed from the elevation data obtained with Orbscan IIz (Bausch & Lomb).
- Vector analysis was performed to combine each pair of higher order aberrations (Z_n^m & Z_n^{-m}).
- Similar analysis method was used to quantify the compensation effects between anterior and posterior corneal surfaces.

In moderate and advanced KC, the total corneal HOA was significantly smaller than anterior corneal HOA due to the posterior corneal compensation effect.



Conclusions

- The posterior corneal aberration is increased with an increase in corneal irregularities.
- Strong HOA compensation effect (coma: ~20%) between anterior and posterior corneal surfaces was found in KC eyes while no compensation was found in the normal eye.
- Uncorrected posterior corneal aberration in KC eyes with a conventional RPG lens can degrade visual performance significantly.

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